I. C. 7425

JANUARY 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

INFORMATION CIRCULAR

JAN 13 1948
O. S. U. LIBRARY

METHODS AND COSTS OF SINKING THE SILVER SUMMIT SHAFT, WALLACE, IDAHO, USING A MECHANICAL MUCKING MACHINE

BY

GEORGE M. GRISMER AND ROBERT J. HUNDHAUSEN

I.C. 7425,
January 1948.

INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

METHODS AND COSTS OF SINKING THE SILVER SUMMIT SHAFT, WALLACE, IDAHO, USING A MECHANICAL MUCKING MACHINE[1]

By George M. Grismer[2] and Robert J. Hundhausen[3]

FOREWORD

In 1946 the Mining Branch of the Bureau of Mines, through its field offices and engineers, renewed the series of information circulars on various phases of mining and milling methods and costs. During the war, emphasis was placed on other investigative problems, with the result that this series was largely discontinued.

The primary purpose of these information circulars is to disseminate technologic data pertinent to mining and milling operations for the benefit of the entire mineral industry.

LOWELL B. MOON,
Chief, Mining Branch.

CONTENTS

Page
Introduction 2
Acknowledgments 2
Purpose of the shaft 2
Geological formations 2
Surface and underground plant 3
Shaft sinking 4
Cycle of Operations 5
  Drilling 5
  Blasting 6
  Mucking 8
  Pumping 9
Cost of sinking 10

---

[1] The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7425."

[2] Superintendent, Polaris Mining Co., Wallace, Idaho.

[3] Mining engineer, Albany Division, Mining Branch, Bureau of Mines.

ILLUSTRATIONS

Fig.		Following page
1.	Plan and sections of the 3,000-foot station and sump	4
2.	Sinking with the Riddell shaft mucker, Silver Summit mine ..	4
3.	Combined skip and cage, Silver Summit shaft	4
4.	Bench round used in the Silver Summit shaft	4

INTRODUCTION

This circular describes the methods and costs of deepening the Silver Summit three-compartment shaft in the Coeur d'Alene mining region of Idaho. A noteworthy rate of advance was achieved at this operation by the successful use of a mechanical shaft-mucking machine.

The Silver Summit mine is 1 mile west from the town of Osburn, Idaho, via U. S. Highway 10. The adit-level portal of the mine is on the south slope of the Coeur d'Alene River Valley at an altitude of 2,700 feet. The Silver Summit shaft is 6,000 feet from the portal. In past years this shaft had been sunk from the adit level to a depth of 1,500 feet. During 1946 the Polaris Mining Co. deepened it to 3,095 feet. The work was done under a cooperative development agreement between the Silver Summit Mining Co. and the Polaris Mining Co.

ACKNOWLEDGMENTS

The authors wish to acknowledge the kindness of L. E. Hanley, president and general manager of the Polaris Mining Co., in giving permission to obtain and publish this information. Charles H. Foreman, chief engineer, and Robert E. Sorenson, chief geologist, of the Hecla Mining Co., supplied valuable information.

PURPOSE OF THE SHAFT

The deepening of the Silver Summit shaft was undertaken as a result of recent ore discoveries in the nearby Sunshine mine. Several vein systems that were noncommercial near the surface contained large and rich lead-silver ore bodies almost a mile below the surface. One of these rich ore discoveries had been made in Polaris ground by workings driven from the Jewell shaft of the Sunshine mine. The Silver Summit shaft was deepened to provide a more centrally located operating shaft for mining the possible eastern extension of this ore and also to afford a base for the deep level exploration of other veins, principally the Silver Summit and Merger veins.

GEOLOGICAL FORMATIONS

The Silver Summit shaft is in the Silver Belt area in the southern part of the Coeur d'Alene mining region. The geology of the area has been described briefly by Shenon and McConnel.[4]

---

[4] Shenon, P. J., and McConnel, R. H., the Silver Belt of the Coeur d'Alene District, Idaho: Idaho Bureau of Mines and Geology Pamph. 50, 2d ed., October 1939.

Underlying the district are pre-Cambrian sedimentary rocks of the Belt series. This series probably exceeds 20,000 feet in thickness and is composed, in ascending order, of the following formations: Prichard, Burke, Revett, St. Regis, Wallace, and Striped Peak. The Silver Summit shaft is entirely in the St. Regis formation. This formation is composed of thin bedded quartzites and argillites. At the 1,500-foot shaft level the beds strike N. 50° E. and dip 65° NW. A gradual uniform change in strike and dip takes place with depth. On the 2,500-foot level the beds strike east-west and dip almost vertically.

The shaft has its long axis oriented almost at right angles to the strike of the formation in the lower levels. Experience in the district indicates that a deep shaft will withstand more rock pressure if the long axis of the shaft is at right angles to the strike of the beds.

The St. Regis quartzite is relatively hard to drill and break. It stands open over large areas. For example, the main underground hoist room is untimbered. Only one vein was intersected in the shaft. This was a quartz-siderite vein, 6 to 18 inches in width. It was crossed at a depth of 2,000 feet. A hard, dark-green, basic dike, 5 feet wide, was encountered at a depth of 2,700 feet in the shaft; it left the shaft at a depth of 2,850 feet.

From 5 to 15 gallons of water per minute entered the shaft through the bedding cracks and joints in the formation. Pumping was not necessary during timbering and subsequent mucking operations, but was required during drilling. The water helped to ventilate the shaft bottom. Pumping operations will be described later in this paper.

SURFACE AND UNDERGROUND PLANT

The Silver Summit workings connect with those of the Polaris mine. Access to both mine areas is provided by the Silver Summit adit, the main haulage level for both mines.

The mill, office, machine shops, and equipment of the Polaris Mining Co. are situated conveniently near the portal of the Silver Summit adit. This surface plant and equipment were originally designed for the operation of the Polaris mine but are now used in connection with the shaft-sinking operations.

The Polaris Mining Co. compressor room and boiler room occupy the ground floor of a building; a large change room occupies the second floor. Two Ingersoll-Rand Imperial type 10, two-stage compressors, supply about 2,200 cubic feet of free air for drilling. Each compressor is driven by a 200-horsepower 2,200-volt Westinghouse motor. A small compressor house owned by the Silver Summit Mining Co. is nearer the adit portal. This building contains two small Ingersoll-Rand compressors capable of supplying 800 cubic feet of free air at about 95 pounds pressure. A 6-inch-diameter airline leads to the underground shaft station, a distance of 6,000 feet. The airline in the shaft is 4 inches in diameter.

The company does not operate a steel sharpening or conditioning shop. All detachable bits for drilling are reconditioned at a modern, well-equipped, independently operated service shop, Bitco Inc., one-half mile from the Polaris mine. More details on the bit-sharpening practice will be described later in this paper.

Shaft timbers are framed at Burke, Idaho, in a carpenter shop belonging to the Hecla Mining Co. The framed timbers are transported 13 miles in a 1-1/2-ton truck from Burke to the mine portal. The timber is framed by a DeWalk framing saw having multiple detachable blades, whereby a cut up to 3 inches in width can be made to a depth of about 5 inches. Horizontal and vertical angles on the cuts are simply adjusted. No hand sawing is required. Whereas in the past it required two men to frame one set in a day, this saw and carriage, operated by one man, will frame two complete sets in a day. Wooden templates are used to insure uniformity in framing measurements.

The underground hoist at the Silver Summit shaft is powered by a 300-horsepower a.c. motor. The hoist is equipped with friction brakes and an air operated multiple-tooth clutch. A 7-1/2-horsepower motor-generator set provides the d.c. circuit used in a dynamic braking motor-control system. The hoist has two drums, each 4 feet in diameter and 4-1/2 feet long. The drums carry 3,500 feet of 1-inch wire rope and are about 60 feet from the shaft. The hoist has a reported rope speed of 800 feet per minute. A rope raise on a 62° slope connects to the top of the shaft, where there are two 50-inch diameter sheaves.

The broken rock is hoisted up the shaft in buckets, which are dumped into a 200-ton-capacity waste pocket excavated in the rock wall about 40 feet above the adit level. From there the muck is drawn into cars through two steel-bottomed chutes equipped with steel half-moon gates. A 6-ton Goodman trolley-locomotive hauls a train of 16 Ajax-type side-dumping cars of 40 cubic feet capacity. The distance to the dump is 6,000 feet. The track is 18-inch gage, with 35-pound rails.

The men go to and from the shaft in specially designed coaches, each transporting 12 men. The coaches are enclosed on top and three sides, with sheet steel for protection.

Electric power is provided by the Washington Water Power Co., Spokane, Wash., and is transformed to 2,300 volts at a substation outside the mill. The power enters the mine adit in an armored, three No. 2 conductor cable. A transformer station at the shaft collar and another at the 1,500-foot leve of the shaft transform the 2,300-volt circuit into 440, 220, and 110 volts a required. An Edison cap-lamp charging station is adjacent to the transforme station at the shaft collar.

SHAFT SINKING

Deepening of the Silver Summit shaft began at the 1,500-foot level on February 1, 1946. The shaft was completed to a depth of 3,096 feet on December 8, 1946. Shaft timbers were placed to a depth of 3,086 feet. Thre stations, each 7 by 8 feet in cross section and about 25 feet long, were driven west from the center compartment at vertical intervals of 500 feet at

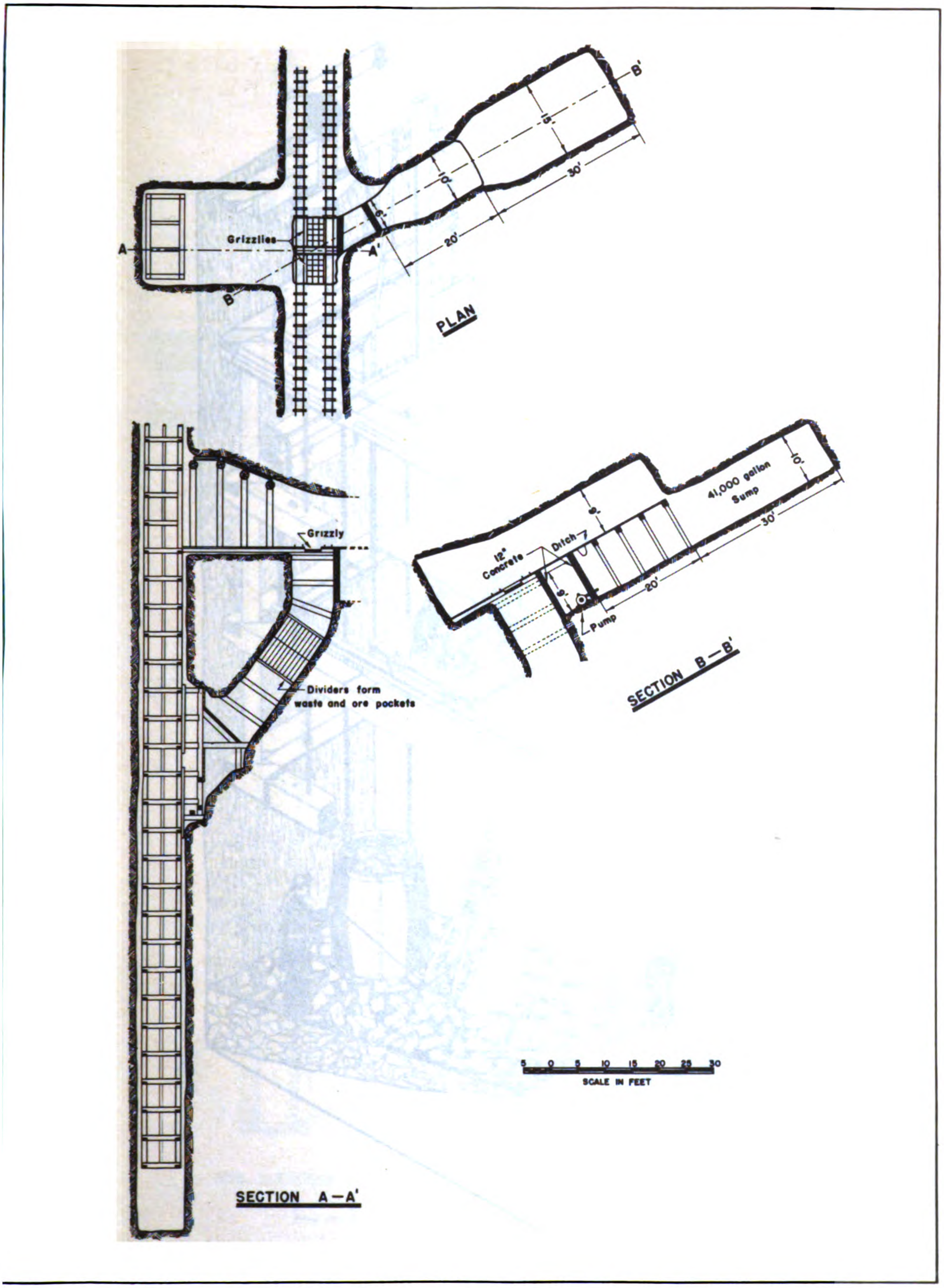


Figure 1. - Plan and sections of the 3,000-foot station and sump.

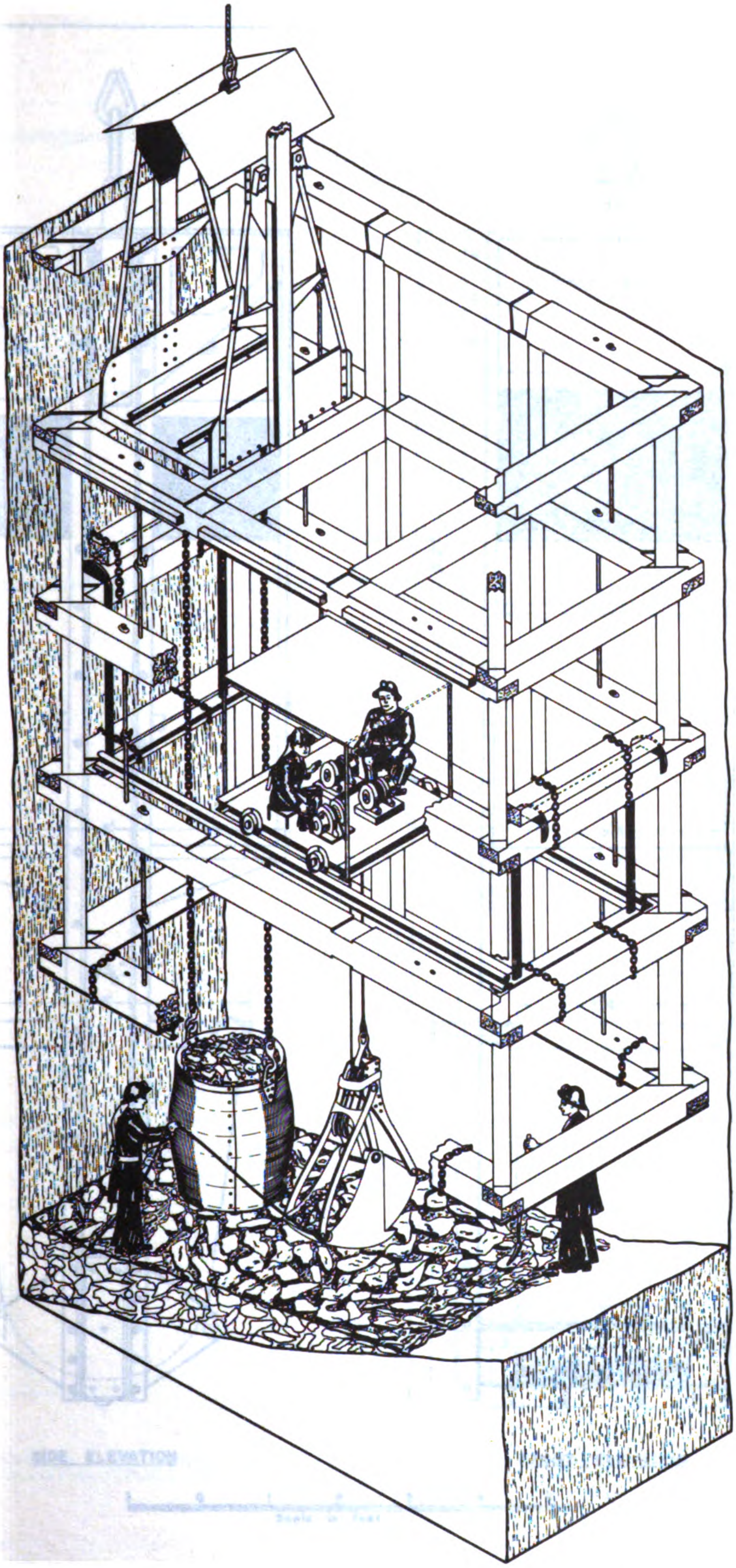


Figure 2. - Sinking with the Riddell shaft mucker, Silver Summit mine.

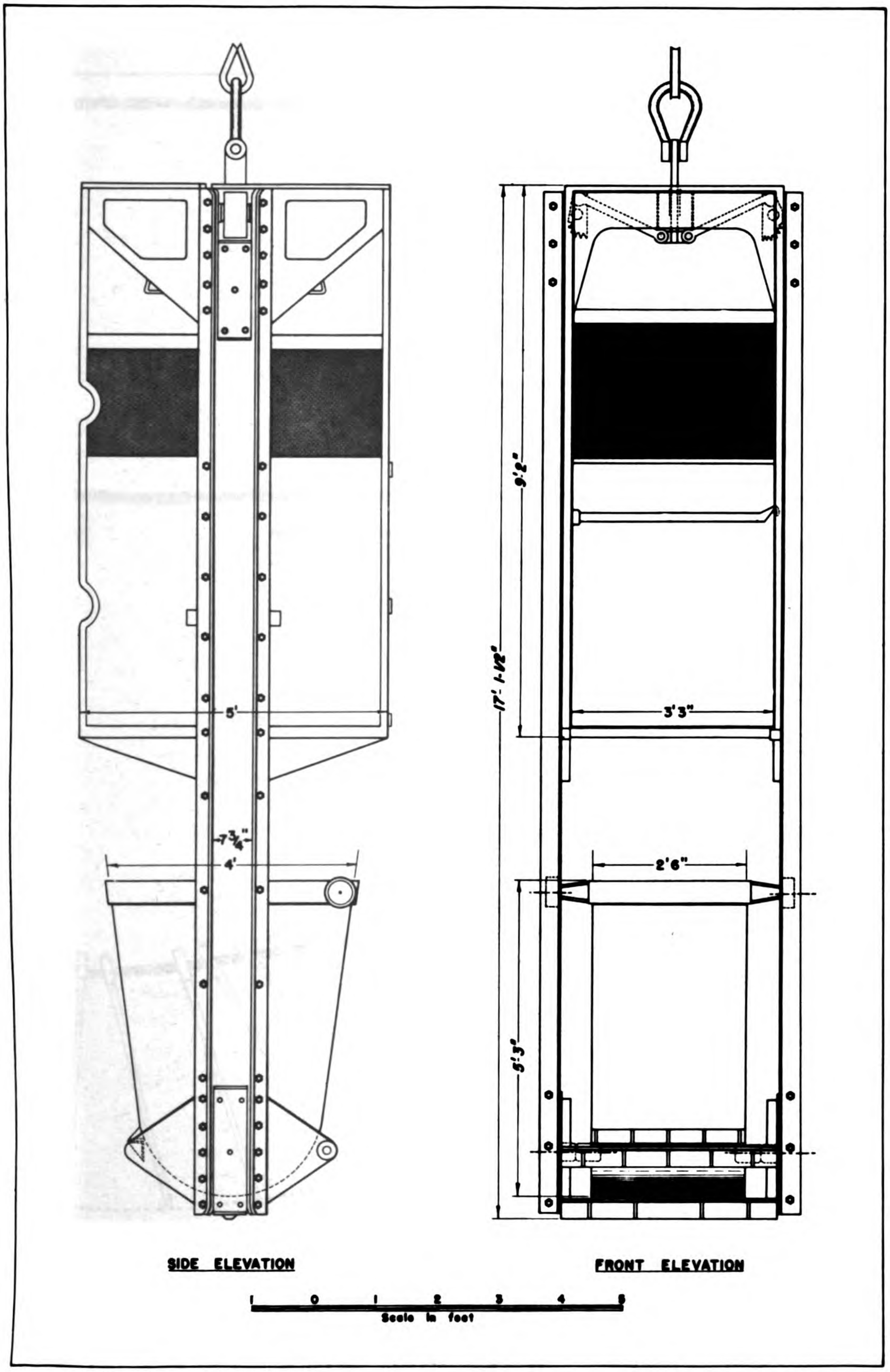
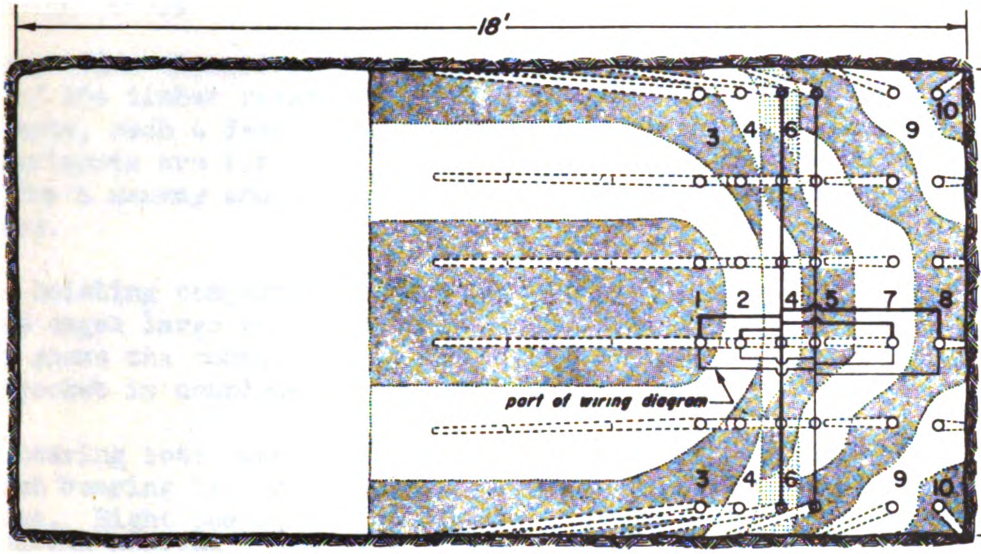
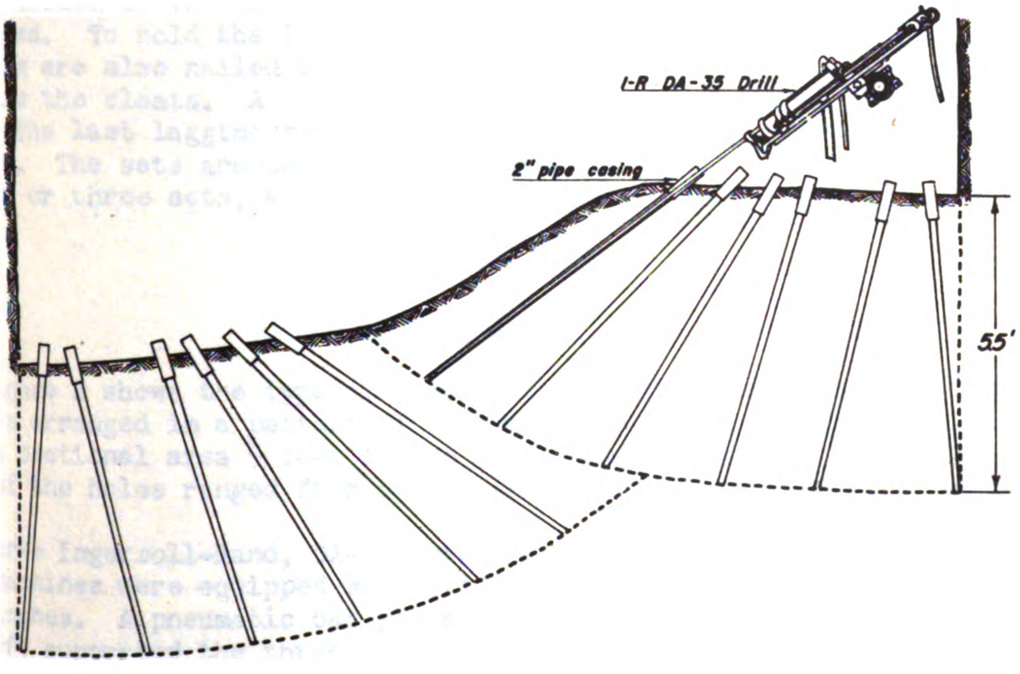


Figure 3. - Combined skip and cage, Silver Summit shaft.



Note: Numbers indicate firing orders

PLAN



VERTICAL SECTION SHOWING TWO SUCCESSIVE ROUNDS

Figure 4. - Bench round used in the Silver Summit shaft.

the 2,000-, 2,500-, and the 3,000-foot levels. Figure 1 shows the plan and sections for the 3,000-foot station and sump.

The outside dimensions of the shaft section averaged 9 by 18 feet. The details of the timber framing are shown in figure 2. The shaft has three compartments, each 4 feet 4 inches by 5 feet 6 inches in the clear. Two of the compartments are for hoisting in counter-balance; the third compartment is used for a manway and contains the water, air, pump-discharge, and vent pipe lines.

The hoisting compartments were designed with an oblong section to accommodate cages large enough to hold loaded timber trucks of 5-foot lagging. Figure 3 shows the combined skip and cage to be placed in service after the station pocket is completed. The skip has a capacity of 42 cubic feet.

No bearing sets were used except at the 2,900-foot level, where two 10- by 20-inch bearing timbers were placed in hitches in the walls to support the end plates. Eight posts, 6 by 8 inches in cross section, space the sets on 5-foot 3-inch centers. The daps for the corner posts are cut 1 inch deep and 6 inches wide on a 45° angle to the wall and end plates. This permits the posts to be driven into position after the set has been hung and tightened.

The shaft sets are lagged on the outside of the timbers. The lagging is 2-inch random-width red fir 5 feet long. The lagging stands on 3- by 3-inch cleats, nailed to the middle of the wall and end plates before the timbers are placed. To hold the lagging firmly against the timber, 2- by 10-inch keyboards are also nailed to the cleats to form slots for the lagging above and below the cleats. A 12-inch space is left for slipping the lagging into place. The last lagging slipped into place is wedged tightly against the keyboard. The sets are usually lagged immediately after timbers are placed. Only two or three sets, at most, were left open before lagging.

CYCLE OF OPERATIONS

Drilling

Figure 4 shows the type of bench round drilled. A round consisting of 36 holes arranged in a pattern of 6 rows of 6 holes each was drilled to break a cross sectional area 9 feet square or one-half of the shaft bottom. The depth of the holes ranged from 6 to 7 feet in length according to the burden.

Three Ingersoll-Rand, DA-35, power-fed drifters were used for drilling. These machines were equipped with sliding cones; they had a feed-shell length of 30 inches. A pneumatic bar placed horizontally across the short axis of the shaft supported the three drills. This bar was 3-1/2 inches in diameter and 8 feet long. To prevent the bar from rotating, one end was equipped with two steel stingers, which usually were inserted into short drill holes in the side wall. A complete round was drilled from one set-up of the bar.

The bench-type method of drilling eliminated considerable hand mucking and provided a drainage sump. It was easily drilled from a bar. Practically no rock was hand-shoveled into the bucket. A small amount of muck was never entirely removed from the shaft bottom. Each bench to be drilled was cleanl swept with the blow pipe. The broken rock was blown into the sump area, where it was picked up with the next round blasted.

All holes were drilled with Timken type-M detachable bits on 1-1/8-inch round, lugged, hollow drill steel. A 2-3/8-inch-gage starting bit was used to a depth of 6 to 10 inches. A short piece of 2-inch pipe casing was then inserted in the hole to keep out rubble. Drilling then continued with eithe a 2-inch or 1-15/16-inch bit. Two foot changes of drill steel were made wit an 1/8-inch decrease in bit gage for each change. The steel lengths were 3, 5, 7, and 9 feet. The average duty per sharp bit was 2 feet of hole.

Reconditioned bits are milled to obtain the minimum possible gage reduction and then sorted to provide sets with approximately 1/8-inch changes. It is stated that this practice adds one or two more uses to the life of each bit.

After a few uses each bit is reduced to the smallest bit gage used, sa 1-1/2 inches. When this size bit is dulled, it is measured in another manne to determine the "stock" or height in the bit between the collar of the wate hole and the cutting edge of the bit. If this thickness proves to be one-fourth inch or more, the bit can be resharpened. The Bitco method of hot milling permits sharpening of the bit to the original gage of 1-1/2 inches by reducing the height of the bit proportionally. Through practice and experience the Polaris Mining Co. has found that the bits will last for anothe use without undue risk of punching the drill rod through the bit. In hard ground, such as the St. Regis quartzite, where bit gage is worn away excessively, this method permits a more efficient utilization of the bit stock, with consequent economies in costs.

Water for drilling was obtained from the 1,500-foot-level sump. A pres sure-reducer valve was installed at intervals in the line to protect the equ ment from excessive pressure.

Air pressure at the machines was about 90 pounds. A 50-foot "bull" hos 1-1/2 inches in diameter, supplied air from the main header in the shaft to the air manifold. The same "bull" hose was used for the mucking machine.

Combined air and water manifolds were used at the shaft bottom. Individual air and water hoses from the three drills were connected to separate outlets on the manifolds. Another outlet on the air manifold provided air for either a blow pipe or an air-driven pump.

It required 2 to 2-1/2 hours to drill a round. At least two rounds wer drilled and blasted during a 24-hour day. The average advance was 5.5 feet per day, two rounds making sufficient room for the placing of one set of timbers.

Blasting

Blasting was done with No. 6 electric detonators wired in parallel to t bare wires across the short axis of the shaft. The firing order and method wiring are shown in figure 4. Each hole was loaded with 3 to 6 sticks of 40-percent special gelatin dynamite and 3 sticks of 60-percent special gelatin dynamite, 1-1/8 by 8 inches in size. The primer at one time was the first cartridge loaded in the hole. After two shaftmen were injured from a blast caused by drilling into or near a missed hole this practice was changed because it was determined that a cap had been in the unexploded cartridge left in the hole. This accident probably could have been avoided if the primer had been the second cartridge loaded. For that reason, the primer thereafter was loaded second.

About 50 percent of the casings used to collar the drill holes were recovered at the chute pocket when the muck was loaded into cars.

The permanent blasting circuit in the shaft is No. 6 gage, soft-drawn copper wire carrying 110 volts. The wire is in a 1-inch, galvanized pipe conduit. A conventional blasting switch is on the 1,500-foot level of the shaft. The shift boss blasted the rounds. Except for the accident mentioned, no trouble was noted from short circuits or misfires.

The primers were made by the shift boss at the collar of the shaft. Each number delay was inserted in its proper position in a wooden box that had 36 "pigeon" holes arranged to simulate the drill-hole pattern at the shaft bottom. The box was oriented in the bottom of the shaft to eliminate confusion as to what primer belonged in what hole. An underground powder magazine is in a crosscut off the main haulage level.

A MT-8, 15-horsepower Coppus fan on the 1,500-foot shaft level exhausted the smoke and gases through a 22-inch diameter, 18-gage, flanged, galvanized pipe. At the collar of the shaft a simple air jet was used as a booster in the pipe line. One hour was required to exhaust the smoke and gas.

A steel blasting set or "battleship" was used to protect the bottom timbers from flying rock. It was built of 3/8-inch steel plate, 12 inches wide, in a rectangle, 16 feet long and 7 feet 2 inches across, conforming in plan to the exact size of the shaft timbers. The plates were reinforced by 20-pound rails welded along the bottom. The four pieces forming the set were bolted together at the four corners by means of four 1-inch bolts. Four chains held the "battleship" against the bottom of the lowest shaft set. Wedges were driven between the chains and the timber to tighten the blasting set further.

The blasting set also was used for a timbering platform. For this purpose, it was suspended from the rim of the bucket in the center shaft compartment by four cables attached to its four corners. Lagging was used as decking to form a working platform. Each wall plate was placed on two 10-inch blocks on the platform, the end plates were doweled to the wall plates, and the timber set was hung and blocked. Dividers were not placed immediately, as these interfered with the mucking machine. The average amount of labor required to place one set of timber was 4 hours crew time or 20 man-hours.

Two plumb lines at diagonal corners of the shaft were used to aline the timbers while blocking them into position. The plumb lines were extended by the company engineer at intervals of 100 feet.

Mucking

When plans were first made by the Polaris Mining Co. to deepen the Silver Summit shaft, L. E. Hanley, president and manager of the company, investigated the possibility of adapting the Riddell shaft mucker to the job. This is a mechanical shaft-mucking machine covered by U. S. Patent 2,326,172. J. Murray Riddell, the inventor and exclusive licensing agent, professor of mining engineering at Michigan College of Mining and Technology, Houghton, Mich., recommended its use after a careful study of the contemplated program.

Sinking began on February 1, 1946. The mucking machine was placed in operation after the fourth round. Two experienced operators arrived to assist in the first operation of the mucker. Within a few weeks, men on each shift were capable of handling the apparatus without further assistance. The shaft mucker in operation is illustrated in figure 2. The mechanism consists of three principal parts: (1) A carriage; (2) a frame; and (3) a clamshell digging bucket. The design of the mucking machine is based on practically the same principles as the more familiar overhead traveling cranes. The clamshell bucket is suspended, lowered, and elevated by means of a model HMK Gardner-Denver air-driven hoist mounted on a movable trolley or carriage. A second identical hoist, also on the carriage, is used to open or close the clamshell bucket. Both hoists are operated by one man riding on the carriage. A second man on the carriage operates a reversible, Gardner-Denver type MPH air-driven geared motor connected by a chain drive to rotate the carriage wheels. This moves the carriage bridge and the suspended load back and forth along the long axis of the shaft. The carriage is on four flanged wheels running on and supported by two 112-pound rails. The rails are rigidly fixed to and supported by H-beams at each end. This supporting framework is suspended from the timber shaft sets by four rigid hanging rods or straps attached to the H-beams near the corners of the frame. The straps have U-shaped hooks for straddling the shaft timbers; these hooks are bolted to the straps and can be readily removed before lowering the framework to the next lower shaft set. As a safety measure, two chains are placed around each H-beam and the adjacent end plate to prevent the machine from falling should a hanging strap break while the machine is in operation.

One rubber air hose, 1-1/2 inches in diameter, connects from the main ai line to the carriage. Distribution of the air to the three motors on the carriage is accomplished by suitable fixed piping fitted with oil lubricators.

The clamshell bucket was made by the Blaw-Know Co. of Pittsburgh, Pa. The bucket has a capacity of 3/8 cubic yard, a width of 20 inches, a length of 6 feet when open, and a weight of 2,020 pounds. It is of the hard-digging heavy-duty type equipped with front, side, and corner teeth.

The clamshell bucket was used only for mucking; it delivered the broken rock to cylindrical, barrel-shaped buckets, each of 30-cubic-feet capacity. These sinking buckets were hoisted in counterbalance; each was attached to the bottom of a man-cage by two 5/8-inch chains, 30 feet long. The chains were removed while the bucket was being filled. The time required to fill the bucket varied from 1-1/2 to 2 minutes, according to the operator's skill and the fineness of the muck. No hand mucking was necessary.

Original from THE OHIO STATE UNIVERSITY

While the muck was being hoisted in one compartment the carriage had to be moved to the manway compartment to make clearance for the downcoming bucket. The empty bucket was lowered within 50 feet of the bottom. The hoistman then flashed a signal light. If all was clear, the signal was returned to the hoistman, and the bucket was then lowered to the bottom of the shaft.

The frame and carriage were lowered one set at a time immediately after a timber set was installed. Before the machine is lowered, the clamshell bucket is first rested on the bottom of the shaft to relieve weight from the supports. The frame, with the carriage centered on it, is attached to the sinking bucket in the middle compartment by four cables hooking over the rim of the bucket. It is then hoisted just enough to enable the four U-shaped straps to be unhooked from the shaft timbers. When so released, the frame is lowered to its new position, the U-shaped straps are hooked over the next lower timber set, and all is again in order for the next cycle.

The time required for changing positions was approximately 12 minutes. Following each blast, about 15 minutes were required to clean the broken rock from the shaft timbers, make hose connections, and prepare the mucker for operation. The average time required to muck out a round was 3 hours.

Blasting tends to lift the frame and carriage off the timber sets; consequently, it was necessary to block the hangers down from the top. This was done by placing a 6- by 10-inch timber, 5 feet long, on top of the hangers and chaining it to the underlying end plate.

In excavating a shaft station the broken rock was scraped out of the levels and allowed to fall to the bottom of the shaft. From there it was mucked into the sinking buckets by the clamshell.

Pumping

From 5 to 15 gallons per minute of water flowed into the shaft. An Ingersoll-Rand air-driven No. 35 sump pump was operated at the bottom of the shaft during drilling operations. While mucking, the clamshell bailed the water into the sinking bucket. The sump pump discharged into a portable 500-gallon steel tank built to fit in the manway compartment of the shaft. An Ingersoll-Rand, 25-horsepower Motorpump, type MRVN, directly beneath the tank, discharged through a 2-1/2-inch fire hose, 50 feet long, into a 2-inch-diameter permanent water column supported in the manway set. From this tank, which was kept 50 to 100 feet above the bottom, the water was successively pumped in lifts of 500 feet to 1,000-gallon steel tanks at each station level. Thus there were three 25-horsepower Motorpumps in all - one at the 2,000-foot level, one at the 2,500-foot level, and the portable pump now at the 3,000-foot level.

This pumping arrangement was used during shaft sinking only. A 41,000-gallon sump is now being excavated on the 3,000-foot level. A Cameron-type, 8-stage, 125-horsepower Motorpump, capable of pumping 150 gallons per minute against a 1,600-foot head, is to be installed at this sump. It will pump to

Original from THE OHIO STATE UNIVERSITY

a similar sump on the 1,500-foot level, where a similar pump will lift the water to the collar of the shaft at the Silver Summit adit level. This pumping arrangement will require a 6-inch-diameter discharge pipe.

Wages, hours, and bonus

The following wage rates were in effect for sinking:

	Per shift
Lead shaftman	$9.75
Shaftman	9.25
Hoistman	9.25
Trolleyman	8.75
Journeyman electrician	8.75
Mechanic	9.00
Shop foreman	11.00
Blacksmith	10.48
Surface laborer	9.25
Truck driver	9.75

The shop foreman worked 6 days a week. The blacksmith and truck driver worked 5 days a week. No compressor operator was employed; it was the duty of the surface men to see that it was operating properly. The shaft-sinking crew worked 7 days a week and received time and a half for all work over 40 hours a week. In addition, a shift differential of 4 cents an hour was added to wages for time worked on the 3 o'clock shift and 8 cents an hour for time worked on the graveyard shift.

The shaftmen and lead men were paid a monthly bonus in addition to their wages, according to the following schedule of monthly progress:

For 52.5 feet of timber progress (ten sets)	No bonus
Next six sets completed	25¢ per set per man-shift
Next six sets completed	50¢ per set per man-shift
All additional sets completed	75¢ per set per man-shift

The hoistmen participated in half the bonus. This was deemed justifiabl because of the close cooperation necessary between the hoistman and the shaft crew. The bonus applied to overtime earnings as well.

COST OF SINKING

The cost of sinking the Silver Summit shaft is shown in table 1. Only direct shaft-sinking costs are given. The company operates a 300-ton mill on a custom-mill basis, so that some of the cost of maintenance and mechanical and electrical work is absorbed by the mill.

The shaft sinking costs in units of labor, powder, and supplies are give in table 2.

TABLE 1. - Shaft sinking costs per foot sunk (834.75 feet progress)

	Labor	Drills, repairs steel, air and water lines	Power	Explosives	Timber	Other supplies	Total
Drilling and blasting	$26.54	$6.62	$2.43	$7.73	$—	$13.59	$56.91
Mucking	27.07	-	-	-	-	-	27.07
Timbering	17.44	-	-	-	9.03	-	26.47
Hoisting	9.97	-	-	-	-	-	9.97
Rock disposal...	1.80	-	-	-	-	-	1.80
Miscellaneous1/	15.27	-	-	-	-	-	15.27
Total direct costs	$98.09	$6.62	$2.43	$7.73	$9.03	$13.59	$137.49

1/ Includes repairs on hoist and equipment, pump installations, rope inspection, skip repair, and timber framing at Burke, Idaho. Further detailed distribution not available.

TABLE 2. - Costs in units of labor, powder and supplies, 834.75 feet sunk

Underground labor	Man-hours per foot
Drilling and blasting	8.502
Timbering	5.586
Mucking	8,670
Miscellaneous	3.251
Total shaft crew	26.009
Foot per 8-hour man-shift, shaft crew only.....	.308
Surface crew	
Hoisting	4.893
Rock disposal	1.648
Surface labor	15.198
Total surface crew	21.739
Foot per 8-hour man-shift, surface	.368
Total crew - shaft and surface	
Man-hours per foot	47.748
Foot per 8-hour man-shift	.168
Ave. daily wage, including bonus	$16.435
	Per foot of shaft
Materials and supplies	
Explosives (40- and 60-percent gelatin dynamite) ..	37.25 pounds
Timber:	Board feet
Shaft set	137
Blocking and lagging	104
Guides	8
Total	249

TABLE 3. - Performance data

Time worked in shaft (1,595.5 feet sunk)	310 days
Average progress per 24-hour day	5.147 feet
Advance per round	2.75 feet
Number of rounds completed	580
Average rate of sinking per month	155.4 feet
Drilling	
Number of holes per round	36
Number of bits sharpened per round	154
Total drilling per round	234 feet
Drilling per foot of advance	85.8 feet

TABLE 4. - List of timbering materials

Item	No. per set	Dimensions	Bd. ft. each	Bd. ft. per set	Bd. ft. per foot
Wall plate	2	10"x10"x16'	133	266	51
End plate	2	10"x10"x7'2"	60	120	23
Divider	2	8"x12"x5'7½"	45	90	17
Post	8	6"x8"x4'7"	18.33	147	28
Lagging		2"x12"x5'		370	70
Cleats		3"x3"x29'		22	4
Keyboards		2"x10"x37'		62	12
Guides	4	4"x6"x16'	32	42	8
Ladders	1	12' long	24	12	2
Blocking		10"x10"x20'		166	32
Miscellaneous staging				10	2
				1307	249